

## **CHAPTER 2. SOURCES OF WORKERS' HOME CONTAMINATION**

### **CHAPTER SUMMARY**

Sources of contamination of workers homes and poisonings of workers' family members reviewed in this chapter include: work clothing; the worker's body; tools and equipment; taking items home from work (such as scrap material); cottage industries (where work is done in or adjacent to the home); farms; and visiting a family member's workplace.

Clothing contamination was documented in 18 reports: 1 on beryllium; 7 on lead; 7 on pesticides; and 1 each on PCB's, an estrogenic substance (zeranol), and 3,4-benzo(a)pyrene. For lead, measurements of both clothing and home contamination were included in some studies. However, these were inadequate for establishing a quantitative relationship between the two. Other evidence of clothing as a source of home contamination includes: high levels of contamination in areas of homes where soiled clothing is stored and laundered (lead, mercury); contamination of washing machines (mercury) or dryers (3,3'-dichlorobenzidine, MOCA); and poisoning of launderers (beryllium, asbestos, lead, kepone).

The workers' body has been considered as a source of home contamination, and showering before leaving work has often been recommended as a preventive measure. However, reports have only documented contamination of workers' hands.

Hand tools and other equipment have been found to contribute to home and vehicle contamination by mercury and pesticides. The potential for contamination of homes by tools was also demonstrated for PCB's and radioactive substances.

Items taken home from work (beryllium-ore bags, cotton shipping-bags for asbestos, cloths from discarded filters, metal drums, contaminated milk, and radioactive scrap lumber) have resulted in serious, and sometimes fatal, poisonings of workers' family members.

Cottage industries, where work is undertaken in the same building or on the property where the family resides have been recognized as a hazard to family members since at least 1914. Cottage industries are the subject of 22 reports of home contamination or family poisonings from asbestos, lead, parathion, and mercury which are reviewed in this chapter. The levels of contamination were often extremely high and the poisonings were severe.

Farms are similar to cottage industries in that families live on the property where work is performed. Three types of products used on farms: pesticides; caustic substances; and estrogenic substances have resulted in several cases of poisoning of family members.

Visiting the workplace of a family member has been shown to be a hazard for families of dry cleaners and veterinarians.

## **CONTAMINATED CLOTHING**

### **Overview**

This section reviews reports that provide evidence for clothing worn, or otherwise taken home from work, as a source of home contamination. The reports are summarized in Table 15. In the health effects studies reviewed in Chapter 1, home contamination and family exposures were often attributed to contaminated clothing brought home from the workplace. This attribution was based on: information elicited by questioning household members; descriptions of workplaces and work practices; and the practice of wearing and laundering work clothes at home. Clothing contamination was documented in 18 reports reviewed below: 1 on beryllium; 7 on lead; 7 on pesticides; 1 on chlorinated hydrocarbons (PCBs); 1 on an estrogenic substance (zeranol); and 1 on 3,4-benzo(a)pyrene. Only for lead were measurements of both clothing contamination and home contamination included in the same studies; these few studies are inadequate for establishing any quantitative relationship between clothing contamination and home contamination.

Other evidence of clothing as a source of home contamination includes: the findings discussed below of high levels of contamination in laundry areas of workers' homes and in areas where contaminated clothing is stored (lead, mercury); contamination of washing machines (mercury) or dryers (3, 3'-dichlorobenzidine, MOCA); and poisoning of home launderers (beryllium, asbestos, lead, kepone). Estimates of exposure levels that could have occurred during home laundering of beryllium and asbestos suggest that such exposures could have exceeded OSHA occupational exposure limits for these substances.

### **Beryllium**

There were no reports of measurements of home contamination by beryllium, although the case histories and epidemiology studies generally assumed that cases of berylliosis in workers' family members were due to laundering contaminated clothing. In support of this assumption, the following studies on clothing contamination indicate that substantial amounts of beryllium dust could have been brought into the workers' homes by contaminated clothing.

Fabrics experimentally exposed at a beryllium production worksite contained beryllium up to 2.8 mg/m<sup>2</sup> [Bohne and Cohen 1985]. In a subsequent study Cohen and Positano [1986], found that work shirts contained from 12 to 37 mg/m<sup>2</sup> of beryllium. It is likely that inhalation exposures of workers' family members occurred during laundering of the contaminated clothing, since resuspended beryllium dust concentrations in air from unwashed shirts at up to 0.64 µg/m<sup>3</sup> were found. In an earlier laboratory study, Eisenbud et al. [1949] found beryllium concentrations in air at 125-1,200 µg/m<sup>3</sup> when soiled clothes

were shaken and estimated an inhalation dose of 17  $\mu\text{g}$  during a single home laundry. The OSHA permissible exposure limit (PEL) for beryllium is 2  $\mu\text{g}/\text{m}^3$  as an 8-hr. time-weighted average (TWA) with permissible excursions up to 25  $\mu\text{g}/\text{m}^3$  for up to 30 minutes (29 CFR<sup>2</sup> 1910.1000).

### **Asbestos**

Several studies of asbestos workers' families inferred that asbestos-related diseases were due to home contamination emanating from clothes contaminated at work, especially due to laundering the clothes [Anderson et al. 1979a,b; Bianchi et al. 1987; Giarelli et al. 1992; Gibbs et al. 1990; Huncharek et al. 1989]. However, no studies evaluated the relationships between home contamination by asbestos, contamination of clothing brought home from work, and exposures during home laundering. The few studies reported and reviewed in this section indicate that clothing probably was a source of home contamination by asbestos and support the hypothesis that home laundering of asbestos contaminated clothing could be especially hazardous.

One study reported measurements of asbestos contamination in workers' homes; however no measurements of clothing as a source of the contamination were made [Nicholson et al. 1980].

Two studies of workplace clothing contamination by asbestos have been reported [Seixas and Ordin 1986; Driscoll and Elliott 1990]. Chrysotile asbestos was found in all clothing vacuumed as employees left work at a brake shoe manufacturing facility, but neither report provided quantitative data on asbestos recovered from the workers' clothing.

No studies of exposure during home laundering were found. However, a study on laundering clothing contaminated by an asbestos removal operation produced an average of 0.4 fibers/ $\text{cm}^3$  while picking up clothing and loading the washer. A maximum of 1.2 fibers/ $\text{cm}^3$  was found during the total laundry operation [Sawyer 1977]. Although the study was not conducted in a home laundry and measurements of the level of clothing contamination that generated these concentrations were not made, the study is consistent with the hypothesis that home laundering of asbestos-contaminated clothing is hazardous. Another important aspect of laundering asbestos contaminated clothing is that the fibers can transfer to uncontaminated clothing washed with the contaminated clothing, as was found by NIOSH [1971] in a study of dry cleaning a coat made with 8% asbestos fiber.

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<sup>2</sup>Code of Federal Regulations. See CFR in references.

## **Lead**

**Overview.** The 18 studies reviewed in this section provide both direct and indirect evidence that lead-contaminated clothing is a source of home contamination.

Lead contamination for both clothing and homes was included in three reports reviewed in this section: one on ore smelter workers; one on a lead products trucker; and one on a radiator repairman. In addition there are two reports on electric cable splicers, one of which reported on clothing contamination and the other of which reported on home contamination. The studies on smelter workers and electric cable splicers, which are the only ones that had comparable data, indicate that contamination of both the smelter workers' homes and clothing was much greater than that of the cable splicers. However the studies are inadequate for establishing a quantitative relationship between levels of contamination in clothes and in homes.

Other evidence presented in this section that clothing is a source of lead contamination in homes includes: (1) additional measurements of clothing contamination; (2) the findings of the highest lead loadings in areas of homes where contaminated clothing was stored and laundered; (3) elevated BLLs in children of parents who wore their contaminated clothing home; and (4) elevated BLLs in home launderers.

**Reports of clothing and home contamination.** Measurements of lead contamination include: concentrations in collected dust, expressed as weight of lead/weight of total dust (e.g.,  $\mu\text{g/g}$  or ppm); or lead loading which is the weight of lead within a square area of surface (e.g.,  $\mu\text{g}/\text{cm}^2$ ).

Homes of secondary lead smelter workers were found by Winegar et al. [1977] to contain lead in house dust at 120-26,000 ppm. In this study, lead concentration in dust of pants cuffs worn under coveralls of two workers were 60,000 and 600,000 ppm and the lead loading of the trouser bottoms of six workers was 280-7,600  $\mu\text{g}/\text{cm}^2$ . There was no correlation between measurements of lead in housedust and the lead loading of trouser bottoms of the six workers. Only 1 of 33 workers showered at work, 8 took work clothes home for cleaning and 21 took home street clothes that were worn under coveralls. There was also no correlation between house dust levels and the type of clothing brought home.

Pollock [1994] found lead at 240  $\mu\text{g}/\text{ft}^2$  (2.2  $\mu\text{g}/\text{cm}^2$ ) on the shoes of a worker who was engaged in trucking lead and lead products; lead up to 0.2  $\mu\text{g}/\text{cm}^2$  was found on surfaces of the worker's home.

Lead carried home from a radiator repair shop was reported by Pitts [1986] and Garrettson [1988]. Wipe samples were collected at various locations in the

home and automobile and from the workers' shoes; data were reported in  $\mu\text{g}/\text{filter}$  but the areas sampled were not reported. Lead in house dust was 183-284  $\mu\text{g}/\text{filter}$  in the bathroom closet where dirty linen was kept and 284  $\mu\text{g}/\text{filter}$  in the kitchen near the washing machine. Other areas of the home were less contaminated. Higher levels were found in the worker's car (1,295  $\mu\text{g}/\text{filter}$  on the driver's seat and 7,580  $\mu\text{g}/\text{filter}$  on the floor of the car). The highest level was found on the worker's shoes (11,030  $\mu\text{g}/\text{filter}$ ). Lead in house paint and in soil outside the house were eliminated as sources of home contamination.

In a study of electric cable splicers, lead concentrations in house dust in the homes were measured by Rinehart and Yanagisawa [1993]. As with the study of battery factory workers' homes [CDC 1977b], the highest concentrations of lead in dust were found in the laundry areas (621-1,606 ppm), but measurements of lead in clothing were not reported. However, in an earlier study of these cable splicers [Venable et al. 1993], their clothing was found to contain lead at 600-4,800  $\mu\text{g}/\text{ft}^2$  (5.7-45  $\mu\text{g}/\text{cm}^2$ ), and their cars contained up to 12,400  $\mu\text{g}/\text{ft}^2$  (17  $\mu\text{g}/\text{cm}^2$ ). Most workers took their soiled clothing home and many of them washed their work clothes with other laundry. Taken together, these two reports, [Venable et al. 1993; Rinehart and Yanagisawa 1993] provide evidence that the electric cable splicers' clothes were contaminated, resulting in subsequent contamination of their homes.

**Supporting studies.** Other studies that provide information on either lead contamination of homes or clothing support the inference of contaminated clothing as a source of lead in homes.

Lead concentrations in dust from seven battery factory workers' homes were studied and found to be highest (average 31,840  $\mu\text{g}/\text{g}$ , maximum 84,000  $\mu\text{g}/\text{g}$ ) in closets where the work clothes were stored [CDC 1977b; Dolcourt et al. 1978]. The average concentration of lead in dust of cars that were driven to work was 2,770  $\mu\text{g}/\text{g}$ . Measurements of the lead-contaminated clothing were not made, but paint, water supply and air were ruled out as sources of lead.

Lead at 1,700 ppm was found in the dust of the home of a worker engaged in cutting down old cables [Osorio 1994]. He wore his work clothing home and laundered it with the family laundry. In a report on workers who soldered or welded with lead, wipe samples were taken from two workers' shoes and the floor under the gas pedal of a car. Shoes had lead at 4-20  $\mu\text{g}/\text{cm}^2$  and the floor had 4  $\mu\text{g}/\text{cm}^2$  [CDC 1992a].

Kaye et al. [1987] measured lead up to 3,400 ppm in vacuum cleaner dust of homes of workers making ceramic-coated capacitors and resistors. Measurements of clothing contamination were not made; however, lead concentrations in the workplace were 50-1,700  $\mu\text{g}/\text{m}^3$  (OSHA PEL 50  $\mu\text{g}/\text{m}^3$ )

the workers wore no protective clothing and there were no shower facilities at work, suggesting that contaminated clothing could have been a source of home contamination.

Lead loadings were determined at various sites in the homes of workers exposed to lead at a bridge site in Ohio [Piacitelli and Whelan 1995]. Measurements of clothing contamination were not reported, except for the highest lead loading of clothing ( $2,278 \mu\text{g}/\text{m}^2$ ), and of the sofa or chair ( $639 \mu\text{g}/\text{m}^2$ ) used by the worker. Paint in the home was excluded as a potential source of the lead contamination.

Cook et al. [1993] found lead in floor dust up to 11,000 ppm, and in window sill dust up to 28,000 ppm in a study of 105 homes in Leadville, Colorado. An unspecified number of workers were engaged in lead mining and smelting; children of those who wore their work clothing home had elevated BLL's. Czachur et al. [1995] found that elevated BLLs of children of workers in a variety of industries were related to the practice of washing dirty work clothing at home. Similarly, Morton et al. [1982] found a significant correlation between the practice of battery workers bringing dirty clothing home and BLLs of their children. Pichette et al. [1989] found that BLLs were elevated in family members who laundered the clothing of battery recycling workers.

Contamination of clothing by lead was documented without any information on home contamination for: (1) workers engaged in abrasive blasting of lead-based paint on a bridge by Ewers et al. [1994a, 1995] who found lead levels as high as  $300 \mu\text{g}/\text{cm}^2$  on work shirts; (2) secondary lead smelter workers by Grandjean and Bach [1986] who found lead up to 2 g/pair of socks; and (3) workers engaged in lining tanks with lead plates (up to  $20 \mu\text{g}/\text{cm}^2$  on shoes and up to  $2 \mu\text{g}/\text{cm}^2$  on shirt collars) [McCammon et al. 1991].

Baker et al. [1977] assumed that contaminated clothing was the source of lead contamination (up to 89,000 ppm) in the homes of the secondary lead smelter workers they studied. This assumption is supported by clothing contamination and house dust studies of smelter workers by Winegar et al. [1977], Grandjean and Bach [1986], and Cook et al. [1993].

### **Pesticides**

A single report of measurements of contamination of workers' homes by pesticides was found [Osorio 1994]. Although this study demonstrated much higher levels of diazinon, chlorpyrifos and propoxur in house dust from floors of farm workers' homes than from floors of non-farm workers' homes, no information on clothing as a source of the contamination was included in the report.

Several reports on contamination of clothing were found; however no associated measurements of home contamination were found. Finley and Rogillio [1969] found up to 12 ppm methyl parathion and up to 136 ppm of dichlorodiphenyl-trichloroethane (DDT) in cloth worn by workers for 8 hrs. in a cotton field the day after spraying. Clothing worn for 30 minutes while working in a freshly sprayed cotton field was analyzed for methyl and ethyl parathion by Ware et al. [1973]. Blue jeans contained 6-16 mg of methyl parathion and about 8 mg of ethyl parathion, whereas T-shirts contained less than 1 mg of each of these contaminants. Finley et al [1977] found methyl parathion at up to 32 ppm in samples of cloth worn during 6 hours of work in a freshly sprayed cotton field, and Graves et al. [1980] found permethrin at 25.8 ppm in a similar study of cotton field workers.

A study of corn-field sprayers' clothing contamination by a water dispersible granule of the herbicide atrazine after 4 hours of work in the field was reported by Oakland et al. [1992]. Atrazine at up to 7  $\mu\text{g}/\text{cm}^2$  of fabric was found.

A pair of coveralls that had been worn during pesticide applications for 4 seasons and washed after each use were analyzed for residual pesticides by Stone and Stahr [1989]. Treflan<sup>®</sup> was found in samples of the coveralls at up to 43  $\text{ng}/\text{cm}^2$ , Lorsban<sup>®</sup> at up to 92  $\text{ng}/\text{cm}^2$ , and Counter at up to 15  $\text{ng}/\text{cm}^2$ , demonstrating the persistence of these substances in contaminated clothing.

Clothing contaminated by pesticides can contaminate laundry equipment [Laughlin et al. 1985; Laughlin et al. 1981; Laughlin and Gold 1988, 1989b] and clothing washed with [Clifford and Nies 1989; Easely et al. 1983; Finley et al 1974; Kim and Wang 1992; Kim et al. 1993; Oakland et al 1989; Braun et al. 1989], or subsequent to [Laughlin et al. 1985; Laughlin and Gold 1989b; Laughlin et al. 1981], the contaminated clothing. Clifford and Nies [1989] found that a uniform on which ethyl parathion was spilled contained 7 g of ethyl parathion/100g of clothing (70,000 ppm) after two washings. Clothes that had been laundered with the originally contaminated uniform contained ethyl parathion at 135-1,500 ppm. Other pesticides that have been shown to transfer to clean clothing when washed with contaminated clothing include: 2,4-dichlorophenoxyacetic acid(2,4-D)ester and amine [Easely et al. 1983]; methyl parathion, toxaphene and DDT [Finley et al. 1974]; atrazine [Kim and Wang 1992; Oakland et al. 1989]; diazinon [Oakland et al. 1989]; and pyrazophos [Braun et al. 1989].

Two reports of family poisonings associated with pesticide-contaminated clothing also provide information on clothing as a source of home contamination. West [1959] found that shoes worn home by a crop sprayer were sufficiently contaminated with demeton to poison the worker's child who contacted either the shoes or the paper towels that were used to clean them.

Two wives who washed the clothes of workers engaged in the manufacture of kepone developed signs of kepone poisoning [Cannon et al. 1978].

### **Chlorinated Hydrocarbons**

Contamination of homes by 3,3'-dichlorobenzidene and 4,4'-methylene-bis(2-chloroaniline) (MOCA) with some evidence of contaminated clothing as the source have been reported. 3,3'-Dichlorobenzidene in vacuum cleaner dust of homes of workers engaged in its production was found at concentrations up to 10.5 ppm and in dryer lint up to 0.74 ppm [ATSDR 1991b]. MOCA was found in vacuum cleaner dust of homes of workers engaged in plastics manufacture at concentrations up to 2.6 ppm and in dryer lint up to 0.65 ppm [ATSDR 1989b].

Contamination of firefighters protective clothing was documented by Kominski [1987a] who found polychlorobiphenyls (PCBs) up to 1,060  $\mu\text{g/g}$  of clothing following a transformer fire. This study adds credibility to the assumption of clothing contamination by PCBs in the several cases where workers' family members developed chloracne.

### **Mercury**

Evidence for clothing as a source of workers' home contamination with mercury derives from observations of clothing contamination, and the finding of elevated mercury concentrations in areas of homes where soiled clothing was stored and laundered. There are no quantitative data on levels of mercury contamination of clothing.

In a study where mercury was used to calibrate scientific glassware, Danzinger and Possick [1973] reported that mercury particles became embedded in the workers' clothing, especially in knitted fabrics. No measurements of mercury contamination in the homes were made, but the author stated that some female workers would shake mercury particles out of their clothing at home.

Workers milling cinnabar ore wore their mercury-contaminated clothing home and contaminated their cars and their homes [Zalesac 1994]. Mercury contamination of workers' clothes contained in plastic bags was confirmed by sampling the air in the bags; mercury was found in workers' cars at 30-60  $\mu\text{g}/\text{m}^3$ , and in workers' homes near washers and dryers at 5-50  $\mu\text{g}/\text{m}^3$ . The occupational exposure limit for inorganic mercury in mining is 50  $\mu\text{g}/\text{m}^3$  as an 8-hr. time-weighted average (30 CFR 57.5001).

Additional support for contaminated clothing as a source of home contamination by mercury is provided by Hudson et al. [1985, 1987] and ATSDR [1990a].

Workers exposed to mercury in a thermometer manufacturing plant also brought work clothes and shoes home and contaminated their homes [Hudson

et al. 1985, 1987]. Mercury concentrations in the air of living areas in the workers' homes were 0.02-10  $\mu\text{g}/\text{m}^3$  compared to 0.01-1  $\mu\text{g}/\text{m}^3$  in control homes. While measurements of clothing contamination were not made, the authors noted that elevated mercury concentrations were found in places where work clothes and shoes were located and in some washing machines.

Workers exposed to high concentrations of mercury during a maintenance operation in a chlor-alkali plant did not shower at the end of the day, and took their work clothing and tools, which were visibly contaminated with mercury, home in their private cars [ATSDR 1990a]. The clothing was washed at home, and the highest concentrations of mercury in the homes were found in the air over washing machines (54  $\mu\text{g}/\text{m}^3$ ) and sinks (7  $\mu\text{g}/\text{m}^3$ ). The mean concentration of mercury in living room air of the 45 contaminated homes was 0.92  $\mu\text{g}/\text{m}^3$  (range 0.1-5.0  $\mu\text{g}/\text{m}^3$ ).

While these studies [Zalesak 1994; Hudson et al. 1985, 1987; ATSDR 1990(a)] did not quantitatively measure mercury contamination of clothing, the findings of high levels of contamination in areas where work clothes were located and in washing machines provide evidence that clothing was a source of the home contamination.

#### **Estrogens**

Measurements of home contamination by estrogenic substances were not found. However, the reports reviewed in this section on documentation of clothing contamination and the effectiveness of measures to prevent home contamination by soiled clothing, support the assumption of clothing as a source of the contamination.

While investigating a pharmaceutical manufacturing plant where children had developed gynecomastia, Aw et al. [1985] found that clothing worn by one of the mothers contained 32 mg of zeranone, a compound with estrogenic properties. The mother washed her clothing at home. Other workers from the plant whose children were similarly effected had also washed their work clothes at home. Specificity of the toxic response together with the documentation of clothing contamination provides evidence of clothing as a source of the children's toxic responses.

Workers engaged in manufacturing diethylstilbestrol wore their soiled clothes home and their children developed signs of estrogen poisoning [Katzenellenbogen 1956]. When controls (special shoes and clothing, showers and laundry) were instituted to prevent home contamination, the health effects were alleviated, providing a basis for the assumption that taking contaminated clothing home was the source of the problem.

### **Other Substances**

Masek et al. [1972] found 3,4-benzo(a)pyrene at up to 14,000  $\mu\text{g/g}$  of clothes in the clothing of workers in a pitch coking plant. No measurements of home contamination were made in this study.

Fibrous glass from contaminated work clothes can be transferred to non-contaminated clothing washed with the contaminated clothing [Peachey 1967; Abel 1966; Madoff 1962].

In the case of silica, one small study indicated that laundering contaminated clothing could be done without contamination of the home area [Versen and Bunn 1989].

### **Infectious Agents**

There is one example where an infectious agent was isolated from clothing contaminated at work [Marmon and Stoker 1956]. In this case, *C. burnetti* was isolated from a shepherd's clothing following an outbreak of Q fever among the shepherd's contacts. In another case, Q fever occurred in family members of workers at a sheep research station. The family members had no contact with infected animals and their infection may be explained by fomite spread [Rauch et al. 1987], perhaps from contaminated clothing.

### **Radioactive Substances**

Documented cases of home contamination by thorium, americium, and an unidentified radioactive substance exist in the Occurrence Reporting and Processing System (ORPS) database of the Department of Energy (DOE) [Boyle 1994]. In the case of thorium, contaminated clothing was taken home and a pillow case became contaminated, the americium was detected on a worker's hat and his child's diaper, and in the other case, the radioactive material was found in the home on personal clothing worn home the previous day.

Files of the U.S. Nuclear Regulatory Commission (NRC) were found to contain three reports of nuclear power workers' clothing being contaminated with potential for, but unconfirmed, contamination of the workers' homes [Brockman 1993]. These files also contain two reports of laboratory workers shoes being contaminated by radioactive phosphorus (P-32) with subsequent contamination of their cars; however, no mention of home contamination was made in the two cases.

## **THE WORKER'S BODY**

Although it is considered good industrial hygiene practice for many work situations to shower before leaving work, and this practice is often recommended to prevent home contamination, there is no quantitative information about contamination of workers' bodies, except for the hands.

Hands of bridge workers engaged in abrasive blasting of lead-based paint were found by Ewers et al. [1994a, 1995] to be contaminated with lead up to 5 mg/pair. Hands of radiator repair shop workers were found by Piacitelli and Rice [1993] to be contaminated with lead at up to 78 mg/m<sup>2</sup> (since the combined surface area of both hands is about 1,000 cm<sup>2</sup>, this equates to about 8 mg of lead on two hands). Hands of utility workers engaged in cable splicing were contaminated with lead at up to 5 mg/ft<sup>2</sup> [Venable et al. 1993] (this equates to about 5 mg of lead on two hands). In an experimental study of fiber contamination on fingers, Schneider et al. [1986] found up to 82 fibers/cm<sup>2</sup> on fingers after contact with dusty surfaces.

### **TOOLS AND EQUIPMENT**

Workers may take their tools and equipment home with them [Hartle et al. 1987] or transport them in company or private vehicles, as in the case of the workers at the chlor-alkali plant in Tennessee who transported mercury contaminated tools in their private cars [ATSDR 1990a]. Although mercury on tools was not measured, the tools were described as visibly contaminated and air in workers' cars contained mercury at 8-10 µg/m<sup>3</sup>. Barnett [1994] described an incident where a pesticide applicator took the company truck home, ready for the next day's work. During the night, chloropicrin leaked from its container and contaminated the worker's driveway and the neighbor's premises.

The NRC files contain a record of finding a radioactive hand tool in a nuclear power reactor contractor's home; in this case, the radioactivity was confined to the tool [Brockman 1993]. The only quantitative measurements of tool contamination found were of PCB contamination of tools used in an aluminum extrusion process [Hartle et al. 1987]. A hand wrench had PCB contamination at 308 µg/m<sup>2</sup> and the external surface of a lunch pail had 14 µg/m<sup>2</sup>; the authors cited contamination limits of 50-250 µg/m<sup>2</sup> for low contact surfaces.

### **TAKING ITEMS HOME FROM WORK**

There are 10 reports that document home contamination by workers taking home contaminated items from work for their own use. This practice resulted in serious poisonings or exposures of family members from beryllium [Chesner 1950], asbestos [Li et al. 1989], lead [Carvalho et al. 1984; Dolcourt et al. 1981; Osorio 1994], pesticides [McGee et al. 1952], hormones [Pacynski et al. 1971], and radioactive lumber [Brockman 1993].

#### **Beryllium**

Beryllium-ore bags were taken home by a worker at a beryllium plant and given to a neighbor woman who used them for dish cloths and who later died from chronic bilateral granulomatous pneumonitis; beryllium at 0.07 µg/100g of lung tissue was found [Chesner 1950].

### **Asbestos**

Asbestos-contaminated cotton cloth bags that had been used to transport molded asbestos insulation were taken home by a worker and used as diapers [Li et al. 1989]; three family members died of mesothelioma at an early age. It should be noted that dirty clothes were also brought home.

### **Lead**

Lead-contaminated cloths from discarded pollution control filters at a lead smelter were taken home by workers for use at home [Carvalho et al. 1984]. The children of these lead workers had a mean BLL of 67.5  $\mu\text{g}/\text{dL}$ . In another case, discarded lead battery casings were taken home for fuel by a worker engaged in recovering lead from used batteries [Dolcourt et al. 1981]. The battery casings were burned in the family's wood-burning stove. House dust contained up to 43,281 ppm of lead; one child had a BLL of 220  $\mu\text{g}/100 \text{ mL}$  and developed encephalopathy with seizures. Osorio [1994] reported that when lead contaminated telephone poles were taken home for fire wood by a worker, the soil in the yard of the worker's home where the poles were located contained lead at 1,500-1,600  $\mu\text{g}/\text{dL}$ .

### **Pesticides**

Toxaphene-contaminated metal brought home from a processing plant resulted in the death of 2-year-old boy [McGee et al. 1952]. The metal, which consisted of flattened strips made from drums that had contained toxaphene, was used to cover the walls of a tool shed on the day the child, who played in the area, was poisoned. In another case, a loaded company truck was parked in an employees driveway overnight [Barnett 1994]. Part of the load was chloropicrin which leaked from the vehicle, poisoning the next-door neighbors.

### **Estrogens**

Diethylstilbestrol poisoning of family members was considered by Pacynski et al. [1971] to be due in part to women bringing home contaminated factory-supplied milk which was consumed by the children.

### **Radioactive Substances**

Radioactive waste lumber was used to construct a garage at home by a worker engaged in the manufacture of catalysts containing depleted uranium. About 20 years later the garage was found to be contaminated in excess of NRC release criteria [Brockman 1993].

## **COTTAGE INDUSTRIES**

Cottage industries, those where work is undertaken in the same building or on the property where the family resides have been recognized as a hazard since at least 1914 [Oliver 1914]. Poisonings by asbestos, lead, parathion, and mercury have occurred in cottage industries.

### **Asbestos**

Asbestos sheets brought home from work were used in a cottage industry to repair burned out mufflers [Epler et al. 1980]. The asbestos sheets were stored in the basement where the children played and were also used to construct a tree house in which the children played. Both children developed asbestos related lung disease at about age 30. Asbestos cement was produced in the basement of another home for about 20 years [Otte et al. 1990]. The mother, father and one son died of mesothelioma some 40 years after the beginning of the exposures to asbestos.

### **Lead**

In addition to the early report by Oliver [1914] of lead poisoning in family members of home pottery manufacture, 14 recent reports on cottage-industry home contamination and poisoning of family members by lead were found, 6 of them involved pottery.

In the report by Oliver [1914], lead at up to 10,000 ppm was found in dust of potters' homes where the pottery was dipped in lead glaze in the same room in which the family lived and slept; lead was also found in the clothes of a young boy and a baby. Koplán et al. [1977] reported on six home potters and their families in Barbados and found BLLs up to 71  $\mu\text{g}/\text{mL}$ , and average concentrations of lead in dust for the six households of 2,333-88,159 ppm with a maximum value of 325,892 ppm. The State of Alabama [1992] reported finding lead at up to 177,000  $\mu\text{g}/\text{ft}^2$  in a home pottery workshop where children with elevated BLLs spent some time; elevated lead levels were also found on the kitchen floor of the family's dwelling.

Other studies of home pottery manufacture did not report levels of contamination, but did report elevated BLLs. BLLs up to 74  $\mu\text{g}/100 \text{ mL}$  were found for children of workers engaged in ceramics (plates, cups, vases, etc.) production at home in Italy [Abbritti et al. 1979]. Molina-Ballesteros et al. [1983] found BLLs up to 98  $\mu\text{g}/\text{dL}$  in children of potters working in their homes in Mexico; and in Japan, Katagiri et al. [1983] reported lead in urine of children of home pottery workers up to 79.3  $\mu\text{g}/\text{L}$  compared to 59.9  $\mu\text{g}/\text{L}$  in control children; 11.2% of children of home potters had lead in urine greater than 30  $\mu\text{g}/\text{L}$  vs. 2.7% of control children. More recently in the United States, Fischbein et al. [1992] reported finding a BLL of 48  $\mu\text{g}/\text{dL}$  in a child of a home potter in New York.

Manufacture, repair and recycling of lead batteries by cottage industries have also resulted in contamination of living areas and exposure of family members. Lead loadings up to 53,140  $\mu\text{g}/\text{m}^2$  were found in households of cottage industry battery repair shops in Jamaica [Matte and Burr 1989; Matte et al 1989]. Matte and Burr [1989] also found that playing in the area of the battery repair shops was an independent predictor of elevated BLLs in children. Other reports did not measure home contamination but reported lead poisoning or elevated BLLs.

Three cases of severe lead poisoning in children whose fathers manufactured lead storage batteries in their homes were reported from the Philippines in 1952 [Anonymous 1952]. An Alaskan battery manufacturing shop investigated by Apol and Single [1980] was located in the building where the owner and his family lived; three of the owner's children who also worked in the shop had elevated BLLs. In a home where battery recycling took place, two children had BLLs of about 65  $\mu\text{g}/100\text{ mL}$  [Dolcourt et al. 1981].

Other cottage industries where family exposures to lead have occurred include: (1) backyard smelters in Jamaica (lead on floors of children's' area at up to 109,000  $\mu\text{g}/\text{m}^2$ ) [Matte et al. 1991]; (2) recovery of gold from scrap jewelry in India [Joshua et al. 1971]; (3) quench hardening of cutlery in Japan; and (4) type printing in Japan [Kawai et al. 1983].

### **Pesticides**

Parathion contaminated sheets that had been purchased by a salvage dealer operating out of his home were used by the family; one child who slept in the sheets was severely poisoned on two occasions [Anderson et al. 1965].

### **Mercury**

Mercury poisoning resulting from its use in homes for extracting gold from sand has been reported on four occasions [Haddad and Stenberg 1963; Hallee 1969; Hatch 1990; King 1954]. In all of these reports, the person doing the extracting was hospitalized; in two cases family members were also hospitalized [Haddad and Stenberg 1963; Hallee 1969]. Mercury excreted in urine over 24 hours by 2 of the extractors were 557  $\mu\text{g}$  and 2,100  $\mu\text{g}$ ; for family members 22-176  $\mu\text{g}$ . One of the extractors had a blood mercury level of 193 mg/dL.

## **FARMS**

Farms and ranches are similar to cottage industries in that families live on the property where work is performed. Three types of products used on farms – pesticides, caustics, and estrogenic substances have resulted in several incidents of poisoning of family members.

Children playing with discarded pesticide containers [Wolfe et al. 1961; Johnston 1953] and pesticide contaminated items [Johnston 1953; Eitzman and Wolfson 1967] on farms have resulted in poisonings by toxaphene and parathion. Farm children also have been poisoned by: drinking from containers, such as cups and soft drink bottles containing pesticides [McGee et al. 1952; Eitzman and Wolfson 1967]; and by playing with or eating pesticides that have been improperly stored [Johnston 1953; Simon 1963; MacMillan 1964].

Caustic products used on farms including dehorning products, disinfectants, drain cleaners and pipe line cleaners containing sodium and potassium hydroxide have been responsible for poisoning of over 40 children on United States farms in recent

years [Neidich 1993; Edmonson 1987; Young 1994; Pelegrin 1995; Geisinger Medical Center 1991; Leach and Leach 1992]. Similar poisonings have been reported from Norway [Christensen 1994]. Often the poisonings result from children drinking the caustic solutions from other than the original containers, e.g., soda bottles. These poisonings have caused second degree burns to the esophagus, esophageal perforation, and in one case death.

Estrogenic substances used in animal feed resulted in poisonings of farm children [Bierbaum 1993]. Farm homes have been shown to be contaminated with fungal spores from barns [Pasanen et al. 1989]. Livestock or wild animals may serve as reservoirs for infectious agents.

### **FAMILY VISITS TO WORKPLACE**

Visiting the workplace is a source of poisoning of family members that has been identified and is relevant to the concept of workers' family protection. Although it deviates somewhat from the concept of the worker contaminating the home by bringing contaminated items home from work, it is similar to cottage industry and farm situations where family members enter the work area.

Lundquist [1980] discussed the hazards of lead contaminated grounds outside the plant where a parent works. Not only can the workers' shoes become contaminated while walking to the car, but also while waiting to pick up a working parent, children may play on the contaminated grounds.

A nursing mother regularly spent her lunch hour with her husband in his dry cleaning establishment [Bagnell and Ellenberger 1977]. Her infant developed obstructive jaundice and her breast milk contained tetrachloroethylene at 1.0 mg/dL. In another study, Aggazzotti et al. [1994] collected alveolar air samples from family members of dry cleaners, and from family members in control homes. Perchloroethylene (tetrachloroethylene) concentrations in alveolar air of family members who visited the workplace were nearly as high at 4.1 mg/m<sup>3</sup> as they were in the dry cleaners (6.56 mg/m<sup>3</sup>). For family members who did not visit the workplace the alveolar air concentration averaged 0.27 mg/m<sup>3</sup> compared to 0.008 mg/m<sup>3</sup> for controls.

Wilken-Jensen [1983] reported that children of a veterinarian suffered from asthma every time they went to work with their father.

## **CHAPTER 3. LEVELS OF CONTAMINATION IN HOMES AND CARS**

### **CHAPTER SUMMARY**

Measurements of contamination in workers' homes and cars were reported for asbestos, lead, pesticides, mercury, a few chlorinated hydrocarbons, arsenic, and fungi (Table 15). However, for the other substances reviewed as contaminants of workers' homes, data on levels of contamination have not been reported; this is true for beryllium, estrogenic substances, asthmatogens, cadmium, fibrous glass, and radioactive substances.

For asbestos, there are no studies of contaminated surfaces, but in one study of the air of workers' homes asbestos concentrations up to one-half of the current 8-hr. time-weighted average OSHA exposure limit for workers were found.

There are many studies of workers' home contamination by lead that document the substantial contamination that has occurred. Lead contamination of surfaces is measured either as concentration of lead in dust, expressed as ppm or as the amount of lead covering an area of surface, expressed as weight of lead per unit of area, and referred to as lead loading.

- When the concentration of lead in household dust was measured, average concentrations in workers' homes ranged from 1,600 ppm to 5,000 ppm with maximum values up to 84,000 ppm. In control homes, concentrations were usually less than 1,000 ppm.
- When lead contamination was measured as weight/unit area, workers' homes had lead loadings that were greater than 2,500  $\mu\text{g}/\text{m}^2$ , ranging up to 109,000  $\mu\text{g}/\text{m}^2$ . Control houses had lead loadings that were less than 1,000  $\mu\text{g}/\text{m}^2$ .
- Lead loadings in workers' cars ranged from 1,000 to 300,000  $\mu\text{g}/\text{m}^2$ . Control cars had lead loadings that were less than 1,000  $\mu\text{g}/\text{m}^2$ .

While measurements of lead in control homes provide some basis for evaluating contamination of workers' homes, guidelines for critical levels of contamination are needed. A value of 500 ppm for the concentrations of lead in dust was used in one study as a threshold for cleaning homes. For lead loading after lead-based paint removal, 2,152  $\mu\text{g}/\text{m}^2$  has been used for floors as a practical, not health-based level. A level of 1,500  $\mu\text{g}/\text{m}^2$  has been stated as a level of concern for children's health.

In three studies of workers' homes contaminated with mercury, concentrations of mercury in air ranging from 0.02  $\mu\text{g}/\text{m}^3$  to 50  $\mu\text{g}/\text{m}^3$  were found. In one study of control homes, concentrations in air ranged from 0.01-1  $\mu\text{g}/\text{m}^3$ . Mercury concentrations in contaminated automobiles were 8-60  $\mu\text{g}/\text{m}^3$ . The MSHA

permissible occupational exposure limit for inorganic mercury vapor is  $50 \mu\text{g}/\text{m}^3$  as an 8-hr. time-weighted average (30 CFR 57.5001).

The few reported measurements of workers' home contamination by pesticides, chlorinated hydrocarbons, arsenic, and fungi also demonstrated high levels of contamination.

### **ASBESTOS**

Only one report on measurements of asbestos contamination in workers' homes was found. Nicholson et al. [1980] reported that chrysotile asbestos in 13 air samples from homes of miners and millers in California and Newfoundland ranged from less than 50 to somewhere in the range of  $2,000 \text{ng}/\text{m}^3$  to  $5,000 \text{ng}/\text{m}^3$  ( $1,000 \text{ng}/\text{m}^3$  equates to about  $0.01 \text{fiber}/\text{cm}^3$  [Cossette 1984]). The OSHA maximum permissible concentrations for workplace exposures are  $0.1 \text{fiber}/\text{cm}^3$  as an 8-hr. average and  $1.0 \text{fiber}/\text{cm}^3$  as a 30-minute average (29 CFR 1910.1001; 1915.1001; 1926.1101).

### **LEAD**

Most of the measurements of lead contamination in workers' homes and cars are of lead concentration in dust expressed as ppm (or the equivalent  $\mu\text{g}/\text{g}$ ) or of lead loading on surfaces expressed as  $\mu\text{g}/\text{m}^2$  or  $\mu\text{g}/\text{ft}^2$  ( $1 \mu\text{g}/\text{ft}^2 = 10.76 \mu\text{g}/\text{m}^2$ ). Similar units are used for expressing measurements of contamination of carpets, furniture, and cars.

**Concentrations of Lead in Dust.** Concentrations of lead in house dust of control homes were reported in several studies. Baker et al. [1977] found lead at an average of 404 ppm in control homes for a study of smelter workers in Tennessee, and Rice et al. [1978] found 1,240 ppm in control homes of secondary smelter workers. In control homes for a study of ceramic workers in Colorado, Kaye et al. [1987] found lead concentrations from non-detectable levels up to 320 ppm. For a study of electric cable splicers, Rinehart and Yanagisawa [1993] found 121-879 ppm, in control homes. Watson et al. [1978] found lead at an average of 718 ppm in housedust of control homes used for a study of battery manufacturing workers in Vermont. As a guideline for cleaning lead contaminated homes in Idaho, an action level of 500 ppm was used [CH<sub>2</sub>M Hill 1991].

By contrast to these control measurements, Baker et al. [1977] found an average concentration of lead in house dust of smelter workers of 2,687 ppm, Rice et al. [1978] found 3,310 ppm in homes of secondary lead smelter workers, Kaye et al. [1987] found lead up to 3,400 ppm in homes of the ceramics workers, Rinehart and Yanagisawa [1993] found lead up to 1,600 ppm in homes of electric cable splicers, and Watson et al. [1978] found an average of 2,239 ppm in homes of battery manufacturing workers.

High concentrations of lead in house dust were also found in other studies of smelter workers, cable workers, and battery manufacturing workers. Smelter workers'

homes in Minnesota were found by Winegar et al. [1977] to be contaminated to about the same extent (median lead concentration 2,400 ppm; range 120-26,000 ppm) as the homes of smelter workers reported by Baker et al. [1977]. Homes of workers cutting down lead cable contained lead in dust at 1,700 ppm [Osorio 1994]. Homes of battery factory workers in North Carolina had lead concentrations in house dust ranging from 1,695 ppm to 84,074 ppm [Dolcourt et al. 1978; CDC 1977b].

Lead in house dust of cottage pottery industries in Barbados contained lead at an average concentration of 5,000 ppm [Koplan et al. 1977]. Homes of workers manufacturing pewter products in Ohio contained lead in window sill dust at 1,700 to 25,000 ppm [Kelly 1994].

Kawai et al. [1983] found 100-5,000 ppm of lead in dust from carpets of cottage-industry homes where work with lead took place. Carpets in homes of workers engaged in manufacture of pewter products contained 675-7,200 ppm of lead in dust [Kelly 1994]. Dust from carpets in homes of foundry workers contained lead at 105-1,535 ppm [Nelson and Clift 1992]. Furniture in a home where lead-battery casings were burned as fuel had lead in dust at 13,283 ppm [Dolcourt 1981].

Concentrations of lead in dust of workers' cars have also been reported. Cars of miners had lead in dust at 3,900 ppm compared to control cars at 917 ppm [Menrath et al. 1993]. Dust in cars of workers manufacturing pewter products contained lead at 700 ppm [Kelly 1994].

**Lead Loading.** For lead loading, that is the total amount of lead per unit surface area, the U.S. Department of Housing and Urban Development (HUD) recommends as feasible levels for samples collected by wipe methods after lead-paint abatement: for hard floors, 200  $\mu\text{g}/\text{ft}^2$  (2,152  $\mu\text{g}/\text{m}^2$ ); and for window sills 500  $\mu\text{g}/\text{ft}^2$  (5,380  $\mu\text{g}/\text{m}^2$ ) [Jacobs 1994]. Only three studies of lead loadings in control homes were found. Abbritti et al. [1989] reported an average of 800  $\mu\text{g}/\text{m}^2$  in homes used for controls in a study of ceramics workers in Italy. Menrath et al. [1993] reported 602  $\mu\text{g}/\text{m}^2$  in control homes for a study of lead miners in the United States, and Matte et al. [1991] reported 690  $\mu\text{g}/\text{m}^2$  in control homes for a study of lead smelter workers' homes in Jamaica.

Lead loadings on floors in homes of backyard lead smelter workers in Jamaica were found by Matte et al. [1991] up to 109,000  $\mu\text{g}/\text{m}^2$  (geometric mean 2,790  $\mu\text{g}/\text{m}^2$ ). About half the homes had peeling paint with 1%-6% lead. In cottage industry battery repair shops in Jamaica, Matte and Burr [1989] found 190-53,140  $\mu\text{g}/\text{m}^2$  in wipe samples from the floors of the workers' homes. Paint samples contained less than 1% lead. Homes of ceramics workers in Italy had lead loadings of 2,700-4,700  $\mu\text{g}/\text{m}^2$  [Abbritti et al. 1989], and in a cottage pottery industry in Alabama, lead loadings of 172  $\mu\text{g}/\text{m}^2$  on a bedroom carpet to 4,196  $\mu\text{g}/\text{m}^2$  on the kitchen floor were found [State of Alabama 1992].

Lead loading of carpets and furniture was reported by CH<sub>2</sub>M Hill [1991]. In this study, lead loadings in carpets and furniture of homes in a lead smelter area were 138,000-2,054,000  $\mu\text{g}/\text{m}^2$  and 613,000-11,118,000  $\mu\text{g}/\text{m}^2$ , respectively.

Lead loadings in automobiles of workers engaged in: removing lead-based paint from a bridge; radiator repair; electric cable splicing; lead welding and soldering; and battery recycling have been reported. Floors of the bridge workers' cars had lead loadings ranging from 340 $\mu\text{g}/\text{m}^2$  to 2,000  $\mu\text{g}/\text{m}^2$  (mean 630  $\mu\text{g}/\text{m}^2$ ); other surfaces had lead loadings less than 500  $\mu\text{g}/\text{m}^2$  [Ewers et al. 1995; Piacitelli et al. (in press)]. Lead loadings in cars of radiator repair workers were up to 96,000  $\mu\text{g}/\text{m}^2$  [Piacitelli and Rice 1993]. Cars of electric cable splicers had lead up to 133,000  $\mu\text{g}/\text{m}^2$  [Venable et al. 1993]. The floor of a car of a worker who soldered and welded with lead had lead at 40,000  $\mu\text{g}/\text{m}^2$  [CDC 1992a]. Cars of workers engaged in battery recycling had lead loadings of 190,000  $\mu\text{g}/\text{m}^2$  on the floor, 300,000  $\mu\text{g}/\text{m}^2$  on the drivers' seat, and 170,000  $\mu\text{g}/\text{m}^2$  on the dashboard [Gittleman et al. 1991, 1994].

### **MERCURY**

Measurements of mercury contamination in workers' homes and cars were reported by ATSDR [1990a], Hudson et al. [1985, 1987], and Zalesak [1994]. Following a single day of exposure to mercury in a maintenance operation, workers contaminated their homes and cars from clothing and tools worn and used at work [ATSDR 1990a]. Mercury concentrations in 25 workers' homes ranged between 1  $\mu\text{g}/\text{m}^3$  and 5  $\mu\text{g}/\text{m}^3$ , and in cars between 8  $\mu\text{g}/\text{m}^3$  and 10  $\mu\text{g}/\text{m}^3$ . When workers in a thermometer plant contaminated their homes, Hudson et al. [1985, 1987] reported mercury concentrations in air of living areas at 0.02-10  $\mu\text{g}/\text{m}^3$  (median 0.24  $\mu\text{g}/\text{m}^3$ ) compared to control homes which had mercury at levels of 0.01-1  $\mu\text{g}/\text{m}^3$  (median 0.05  $\mu\text{g}/\text{m}^3$ ). Zalesak [1994] reported that contaminated homes of gold mine workers had concentrations of mercury near washers and dryers at 5- 50  $\mu\text{g}/\text{m}^3$  and their cars had mercury concentrations at 30-60  $\mu\text{g}/\text{m}^3$ . The MSHA permissible occupational exposure limit for inorganic mercury vapor [30 CFR 57.5001] is 50  $\mu\text{g}/\text{m}^3$  as an 8-hr. time-weighted average.

### **CHLORINATED HYDROCARBONS**

Concentrations of 3,3'-dichlorobenzidine (DCB) in vacuum cleaner dust from homes of workers engaged in its manufacture were at 10.5 ppm [ATSDR 1991b]. House dust in homes of workers exposed to PCBs contained PCBs at concentrations up to 180 ppm [Price and Welch 1972]. No guidelines exist for judging the significance of these contaminant concentrations. No other measurements of home contamination levels for this class of compounds were found.

### **PESTICIDES**

Concentrations of diazinon, chlorpyrifos, and propoxur were found at much higher concentrations in floor dust collected in farmworkers' homes than in non-farmworkers' homes [Osorio 1994]. Diazinon was found at averages of 56  $\mu\text{g}/\text{m}^2$  and 39 ppm in four of five (not detected in the fifth home) farmworkers' homes

compared to 0.29  $\mu\text{g}/\text{m}^2$  and 0.19 ppm in the one non-farmworkers' homes where it was found. Chlorpyrifos was found in three of the five farmworkers' homes at averages 6.9  $\mu\text{g}/\text{m}^2$  and 11.1 ppm compared to 1.1  $\mu\text{g}/\text{m}^2$  and 0.71 ppm in the one non-farmworker's home in which it was found. Propoxur was found in one farmworker's home at 16.9  $\mu\text{g}/\text{m}^2$  and 0.52 ppm compared to 0.15  $\mu\text{g}/\text{m}^2$  and 0.10 ppm in the one non-farmworker's home in which it was found. Twelve other pesticides were found at low levels in some homes of both farmworkers and non-farmworkers.

Since pesticides have many applications and some, such as DDT, are very stable compounds, it is important to determine sources of pesticides when evaluating workers' home contamination. Lewis et al. [1994] found a total of 23 pesticides in 9 homes in North Carolina. From 8 to 18 different pesticides were found in individual homes. No guidelines for levels of concern for contamination of workers' homes by pesticides were found.

#### **ARSENIC**

Dust in homes of workers exposed to arsenic in Hawaii contained arsenic at 5.2 to 1,080 ppm, compared to 1.1-31 ppm in dust of control homes [Klemmer et al. 1975]. Guidelines by which to judge the significance of these contamination levels were not found.

#### **INFECTIOUS AGENTS**

Concentrations of fungal spores in farm homes in Finland were  $10^4$ - $10^5/\text{m}^3$ , which was 10-1,000 times the concentrations found in urban homes [Pasanen et al. 1989]. Reports of contamination levels for other infectious agents in workers' homes were not found.

## **CHAPTER 4. PREVENTIVE MEASURES**

### **CHAPTER SUMMARY**

Several measures that have been taken to prevent contamination of workers' homes and to protect workers' families are identified in the reports reviewed in this Chapter. The measures include:

- reducing exposures in the workplace;
- changing clothes before going home and leaving the soiled clothing at work to be laundered by the employer;
- storing street clothes in separate areas of the workplace to prevent their contamination;
- showering before leaving work;
- prohibiting taking toxic substances or contaminated items home;
- separating work areas from living areas of cottage industries;
- storing and disposing of toxic substances on farms and in cottage industries properly;
- preventing family members from visiting the workplace;
- laundering separately from family laundry when it is necessary to launder contaminated clothing at home; and
- informing workers of the risk to family members from home contamination and ways to prevent it.

The few studies evaluating these measures indicate that they can be effective in reducing or eliminating home contamination. There have also been instances in which home contamination has occurred when one or more of these measures has been omitted.

### **BERYLLIUM**

Following reports of occupational and non-occupational (community and workers' families) cases of berylliosis, the beryllium industry instituted a number of preventive measures, including: engineering controls to reduce air-borne exposures of workers'; community air pollution controls; and measures to prevent exposure of family members to contaminated clothing [Eisenbud et al. 1949; Metzner and Lieben 1961]. In one plant, a double locker system was installed in 1955 which prevented removal of work clothes, underwear, socks and shoes from the facility [Lieben and Metzner

1959]. Until Newman and Kreiss [1992] reported on a case, there were no new cases of berylliosis in beryllium workers' families reported for more than 30 years. This recent case report demonstrates the dangers of any relaxation of preventive measures as the uses of beryllium, the number of workplaces where it exists, and the number of workers exposed expand.

### **ASBESTOS**

Although poisoning of asbestos workers' families has been known since the report by Newhouse and Thompson [1965], and has been repeatedly associated with laundering contaminated clothing, no information exists on effectiveness of preventive measures. Belanger et al. [1979] recognized the hazard in evaluation of a factory where asbestos was used in the manufacture of floor coverings. They specifically recommended that work clothes not be taken home because this could expose others at home.

Seixas and Ordin [1986] and Driscoll and Elliott [1990] investigated plants manufacturing brake linings and made recommendations for providing protective clothing, keeping street clothes separate from work clothes, company laundering and showering before leaving work. The OSHA asbestos standards [29 CFR 1910.1001, 29 CFR 1915.1001, and 29 CFR 1926.1101] require these actions when employee exposures exceed 0.1 fiber/cm<sup>3</sup> averaged over 8 hrs. or 1.0 fiber/cm<sup>3</sup> averaged over 30 minutes. In the absence of information on clothing and personal contamination levels when workers are exposed to asbestos at concentrations below these limits, the adequacy of the OSHA standards for protecting workers' families cannot be judged.

### **LEAD**

The report of an investigation of a stained glass window-making studio [Donovan 1994a,b], documented that the use of controls by the studio effectively prevented lead contamination of the worker's home that was adjacent to the studio. Preventive measures used at the studio included local exhaust ventilation during soldering, general dilution ventilation equipped with an electrostatic filter, adhesive mats at doorways to decrease the migration of lead dust on shoes, a laundry room located between the studio and the house that was also used as a changing room, designated work clothing that was only worn in the studio, washing work clothes separately from other clothes, prohibiting work shoes from leaving the studio, and prohibiting the child from entering the studio. Based on the results of surface-wipe sampling, which demonstrated elevated lead levels in the studio (1.2 mg/m<sup>3</sup> to 1,600 mg/m<sup>2</sup>) but not in the home (non-detected or trace), the author concluded that the measures used prevented contamination of the home. The Lead Industries Association, Inc. has produced a video tape entitled "Controlling Lead Exposure for Stained Glass Professionals and Hobbyists" [LIA 1994a].

In another cottage industry, a home-pottery operation, the concerned potter and her family were asked to discontinue being exposed in the facility because of their elevated BLLs [Fischbein et al. 1992]. Two years later, the BLLs were normal, indicating that corrective measures, though not described, were effective. The Lead

Industries Association, Inc. has produced a video tape entitled "Control of Lead Exposure in the Ceramics Industry" [LIA 1993b].

Piacitelli et al. [in press] studied contamination in cars of workers engaged in removing lead-based paint from a bridge. They found that lead contamination was lower in cars of abrasive blasters ( $379 \mu\text{g}/\text{m}^2$ ) than in those of other workers ( $1,100 \mu\text{g}/\text{m}^2$ ). Abrasive blasters had the highest air-borne exposures at the worksite, but regularly changed clothes and showered before entering their vehicles whereas the other workers (industrial hygiene/safety and security personnel) did not. This study provides evidence of the effectiveness of the preventive measures, but also indicates that the measures should be extended to the lesser exposed workers. The OSHA lead standard for construction workers (29 CFR 1926.62) does not require showering and changing clothes unless exposures exceed  $50 \mu\text{g}/\text{m}^3$  as an 8-hr. time-weighted average.

Rinehart and Yanagisawa [1993] found that even though electric cable splicers shower and change clothes at work, they contaminate their homes by taking their contaminated clothing home to wash. Since these workers' exposures are less than the OSHA standard of  $50 \mu\text{g}/\text{m}^3$  (29 CFR 1910.1025), employers are not required to launder the employees' clothes.

Excessive lead exposure was identified for workers at a battery factory and for some of the workers' children [CDC 1977b]. The factory initiated a program designed to reduce worker and family exposures. Plant processes, including exhaust ventilation systems, were improved and coveralls and improved shower facilities were provided. Under the direction of the local health department, the homes of the affected children were thoroughly cleaned.

Morton et al. [1982], in a study of BLLs in children of workers engaged in battery manufacture, found that only changing clothes at work did not reduce the risk of elevated BLLs in the workers' children. They recommended showering before leaving work in addition to changing clothes. Similar findings were reported for backyard battery repair shops [Matte and Burr 1989; Matte et al. 1989] where changing from work clothes before entering the home did not result in lower concentrations of lead in housedust.

An article specifically directed at protecting lead battery workers' families was published in *Battery News* in 1980 [Lundquist, 1980]. This article informs the readers that levels of contamination that may be considered innocuous in the workplace may be of concern in the home where children are exposed and daily exposures are for 24 hours. The article also informs the readers of several sources of home and automobile contamination. In addition to the workers body and clothing, the reader is advised of the hazard of children visiting the workplace and taking home contaminated items such as scrap or surplus material.

Baker et al. [1977] reported on an investigation of a secondary lead smelter. The authors state that "Since this investigation, remedial action has taken place at the smelter and in the workers' homes to reduce lead exposure: work clothes are no longer worn home, workers shower before leaving work, plant processes have been redesigned to reduce lead exposure, and homes have been thoroughly cleaned." Although it is not clearly stated, the article implies that the remedial action was taken in response to the results of the investigation. The effectiveness of preventive measures was not determined.

The Lead Industry Association [LIA 1989; 1991; 1993a,b; 1994a,b] has produced brochures, flyers, and videotapes that provide information for a wider audience that is relevant to preventing workers' home contamination.

### **CAUSTIC FARM PRODUCTS**

After incidents in which children were poisoned by caustic farm products, farm journals published preventive measures [Morris and Morris 1992, 1993; Devries and Devries 1993; Jorgenson 1990]. Morris and Morris [1992, 1993] designed a storage box with a child-proof lid and this design was published in *Hoard's Dairyman* in 1992 and in the *Farm Journal* in 1993. Another design for storing hazardous chemicals in dairy barns was also published in *Hoard's Dairyman* in 1993 [Devries and Devries 1993]. Several precautions that farmers need to take with caustic dairy cleaners were enumerated by Jorgenson [1990]. These include:

- rinsing the measuring containers immediately;
- mounting the original container and attachments out of children's reach;
- leaving labels on containers;
- never storing chemicals in food containers, soda bottles, or cups;
- storing chemicals in a locked storage area out of a child's reach; and
- properly disposing of empty containers. "Don't leave them--even rinsed ones--around for children to find."

### **PESTICIDES**

Barnett [1994] reported on a pesticide spill (chloropicrin) that occurred at the house of an employee who was preparing a work vehicle for a 12-day trip to treat utility poles. Next door residents, two adults and three children, became ill and the local fire department was called to clean up the spill. As a result of this incident, the employer instituted workplace changes which included a policy that company vehicles were not to be taken home, and that appropriate storage and means to secure containers while transporting chloropicrin be used.

Finley et al. [1977] demonstrated that delaying entering a field for 4 days after spraying with methyl parathion reduced clothing contamination by 99% from that on the first day after spraying. Thus delayed entry would substantially reduce exposure of launderers and potential for contamination of laundry equipment.

A number of publications have addressed hazards to workers and to workers' family members and advised on preventive measures [Wyant-McNutt 1983; Lavy 1988; Branson and Henry 1982; Rigakis et al. 1987; Easley et al. 1981a; Laughlin and Gold 1989c; Stone and Wintersteen 1987; Anonymous 1994; Finley et al. (no date)]. Several of these publications are pamphlets produced and distributed by Agricultural Experiment Stations and Extension Services to advise workers and their families on proper procedures for handling and laundering the pesticide contaminated clothing, based on research reviewed in Chapter 5 and summarized in Table 16. Briefly the recommendations in these publications and pamphlets for handling and laundering clothing contaminated with pesticides include:

- Discard or burn heavily contaminated clothing (e.g., after a spill);
- Store soiled clothing separately from other clothing;
- Use rubber gloves when handling soiled clothing;
- Launder soiled clothing separately from other clothing;
- Launder contaminated clothing after each use, and on the day of use, if possible;
- Laundry methods should include a pre-wash treatment, heavy duty detergent, hot water (e.g., 60°C), a complete wash cycle, full water volume, a wash time of 12-14 minutes, and a double rinse;
- Clean the washing machine after laundering contaminated clothing by running the machine through a complete cycle with a full volume of water and detergent; and
- Line air dry the clothes to avoid contamination of an automatic dryer and to allow sunlight and time to further reduce the toxic residues.

Four surveys on how workers and workers' family members handle pesticides or contaminated clothing have been reported. The first survey, conducted in 1982, was of licensed professional agricultural workers in Louisiana [Cloud et al. 1983]. More than half of the respondents were unaware of the existence of disposable protective garments, and the common clothing worn was short sleeved shirts and denim or khaki pants. Home laundering was the rule, the clothes were usually stored in clothes hampers and laundered within two days of use. About 30% of the respondents laundered the contaminated clothing with other family clothing, and none reported using any pretreatments.

Grain growers in Alberta, Canada who did their own pesticide application were asked to respond to a laundry practices questionnaire in 1984 [Rigakis et al. 1987]. The persons who did the laundry (97% were wives) were the responders. In 34% of the families, other family members assisted with the laundry. Pesticide contaminated clothing was stored apart from other clothing prior to laundering by 62% of the responders, 59% washed contaminated clothing separately from other clothing, and 60% used pre-wash treatment of the clothing. However, only 18% of the responders reported washing the contaminated clothing on the day it was used, only 25% used water heated to the usually recommended temperature, 73% used less detergent than recommended on the container, 76% used a clothes dryer, and only 6% used rubber gloves for handling contaminated clothes. Based on these results, information on handling and laundering contaminated clothing was developed and distributed to farmers.

In 1983, a pamphlet entitled "What to Do when Clothes Are Soiled With Pesticides" was published by the Iowa Cooperative Extension Service [Stone and Wintersteen 1988]. A survey of laundering practices among farm families was conducted in 1984 [Stone et al. 1986]. The recommendations made in 1983 appear to have influenced laundry practices in Iowa. The findings of this survey of 368 registered pesticide applicators indicated much better laundry practices in Iowa, than were found by Cloud et al. [1983] in Louisiana. Nearly all (98%) of the applicators' clothing was washed at home and most families (greater than or equal to 90%) stored and washed the soiled clothing separately from other clothing. Full water levels were used by three-fourths of the launderers and about half used hot water. However, 68% of the launderers did not clean the washing machine after washing the contaminated clothing and 73% did not destroy clothing on which concentrated liquid pesticides had been spilled. The recommendations made in 1983 appear to have influenced laundry practices in Iowa.

Pesticide applicators (23) and farmers (15) in California responded to a questionnaire that solicited information on their attitudes about some factors relevant to family protection [Rucker et al. 1986]. The applicators all considered that it wasn't safe for children to be around when they were working with pesticides; the growers were less certain on this item. When asked where they stored their contaminated clothing, most of them responded that they never stored their clothes with the family laundry or in closets with other clothes. Also, most of them reported that the contaminated clothing was always washed in separate loads from other clothing; however, most of them did not pre-rinse the clothing before washing and most of them used a single wash.

## **HORMONES**

Effectiveness of controls in the manufacture of diethylstilbestrol in eliminating the hyperestrogenic signs in the children of workers who manufacture the compound was documented by Katzenellenbogen [1956] and Pacynski et al. [1971]. The preventive

measures included use of gloves, special shoes and clothing, and laundering of work clothes by the company.

#### **ASTHMATOGENS/ALLERGENS**

Two case studies of workers' spouses who had allergic reactions to antigens brought home by their spouse indicate that the practices of showering and changing clothes before leaving work were effective at preventing the allergic reactions. In the first case, the antigen was of animal origin which the wife brought home on her clothing and body from the research laboratory where she worked. The symptoms of the worker's husband resolved after the worker began wearing different clothes at work and at home, and showering and washing her hair before leaving work. In the second case, the antigen was platinum salts which the husband brought home on his clothing and body from his work at a precious metals refining company. The symptoms of the worker's wife resolved after her husband's company instituted a policy that employees should shower and change clothes before leaving work.